

Examination topics of
Mathematical Introduction to QFT
Jan Dereziński, Winter Semester 2023/24

1. Joint spectrum of the energy-momentum in relativistic quantum mechanics
2. $*$ algebras and their representations, especially in finite dimension.
3. Haag-Kastler axioms of QFT.
4. Wightman axioms of QFT.
5. Green's function of the Helmholtz equation.
6. Various propagators and 2-point functions of the Klein-Gordon equation.
7. Various propagators and 2-point functions of the (massless) wave equation in 1+3 dimensions.
8. Tensor product of Hilbert spaces. Fock spaces.
9. Creation/annihilation operators—rigorous definition and commutation relations.
10. Operators $\Gamma(\cdot)$ and $d\Gamma(\cdot)$ in the second quantization.
11. From the Hamiltonian to Lagrangian formalism and back.
12. Representations of canonical commutation relations and the Stone-von Neumann Theorem.
13. Free scalar field in the Lagrangian and Hamiltonian formalism.
14. Quantum free scalar bosons and their 2-point functions (commutator, non-time-ordered and time-ordered).
15. Time-dependent Hamiltonians and the scattering operator.
16. Gaussian integral in several dimensions.
17. Generating functions of a symplectic transformations and the integral kernel of Bogoliubov implementers (operators implementing symplectic transformations).
18. Path integrals for quadratic Hamiltonians.
19. Scalar field with a mass-like perturbation in the Lagrangian and Hamiltonian formalism.
20. The renormalization of the vacuum energy for a mass-like perturbation.